INDOOR AIR QUALITY ASSESSMENT

Atkinson Elementary School
111 Phillips Brooks Road
North Andover, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
October 2002

Background/Introduction

At the request of a parent and Mr. Paul Szymanski, Director of Management Support Services for the North Andover School Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Atkinson Elementary School in North Andover, Massachusetts.

On March 28, 2002, Cory Holmes, Environmental Analyst for the Emergency Response/Indoor Air Quality Program (ER/IAQ), BEHA, and Suzan Donahue, ER/IAQ Research Analyst visited the school to conduct an indoor air quality assessment. BEHA staff were accompanied by Leslie Sheadas, School Custodian, for portions of the assessment.

The school is a two-story brick building constructed in 1964, originally as a junior high school. The school was converted to an elementary school and a modular classroom was added to the rear of the building in the late 1980s. A second modular classroom was added in 1998. The school currently houses grades 1-5. The second floor is made up of general classrooms. Located at ground level are general classrooms, library, school nurse, computer room, cafeteria/auditorium, kitchen, teachers' dining room, gymnasium, music room, art room and office space.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school has a student population of 292 and a staff of approximately 40. Tests were taken during normal operations at the school and results appear in Tables 1-5.

Discussion

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in sixteen out of twenty-eight areas surveyed, which indicates a ventilation problem in these portions of the school. It is important to note that a large number of classrooms had open windows during the assessment, which can contribute to reduced carbon dioxide levels. It should also be noted that several classrooms had elevated carbon dioxide levels without occupancy, further indicating inadequate ventilation.

Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were found deactivated in many areas. Univents in this wing do not run continuously but are activated by thermostats once room temperatures drop below a set level. When the room temperature exceeds the thermostat setting, univents deactivate. Without mechanical ventilation running continuously, fresh air cannot be introduced into classrooms on a consistent basis. Obstructions to airflow, such as paper and boxes stored on univent air diffusers and items in front of univent return vents, were also noted in classrooms (see Picture 1). In order

for univents to provide fresh air as designed, univent air diffusers and return vents must remain free of obstructions. Importantly, these units must remain activated while classrooms are occupied.

The mechanical exhaust ventilation system in classrooms consists of grated, wall-mounted exhaust vents. A number of exhaust vents were obstructed by tables, chairs, boxes and other items (see Picture 2). The location of exhaust vents can also limit exhaust efficiency when the classroom hallway door is open. When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom (see Picture 3). The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms. Exhaust ventilation in the music room, cafeteria and gymnasium were off or drawing weakly. The exhaust vent for the cafeteria was found occluded with accumulated dust/debris, which can decrease airflow into the vent (see Pictures 4 & 5). Without removal by the exhaust ventilation, normally occurring environmental pollutants can build up and lead to indoor air complaints.

In order to have proper ventilation with a univent and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. According to school department officials, the date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that

the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix I.

Temperature readings ranged from 70^{o} F to 79^{o} F, which were very close to the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. Temperature control complaints were expressed to BEHA staff in room 20 and in the gym. In many cases concerning indoor air quality,

fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 18 to 33 percent, which was below the BEHA recommended comfort range. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several classrooms contained a number of plants. Plant soil and drip pans can serve as a source of mold growth. Plants should also be located away from univents and exhaust ventilation to prevent aerosolization of dirt, pollen or mold.

A few classrooms had water-damaged ceiling tiles which can indicate leaks from either the roof or plumbing system (see Picture 6). Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

Standing water was noted on the roof of the main entrance awning and on the roof at the junction of the original building and the modular classrooms. The drain for the Modular classroom awning was clogged with debris. The collection of water and its subsequent freezing and thawing during winter months can lead to roof leaks resulting in water penetration into the interior of the building. Pooling water can also become stagnant, which can lead to mold and bacterial growth, resulting in unpleasant odors. Standing water also provides a breeding ground for mosquitoes in warmer months.

Water vapor was observed collecting within a double-paned glass window of a modular classroom (see Picture 7). This condition indicates that the window's water seal is no longer intact. Repairs of window leaks are necessary to prevent further water penetration. Repeated water damage can result in mold colonization of window frames, curtains and items stored on windowsills.

An area of possible water penetration may be along expansion joints and/or the junction of the foundation and the exterior wall system of the building. Expansion joint sealants were weathered, mechanically damaged or missing (see Pictures 8 & 9). Some of the expansion joints may allow for water to penetrate into the interior of the building.

Small trees and other plants were also seen growing in the tarmac/exterior wall junction (see Picture 10). The growth of roots against the exterior of foundation walls, as well as spaces between the tarmac, can bring moisture in contact with brick and foundation structures, which may eventually lead to moisture penetration below ground level areas of the building.

Modular Classroom

The modular classroom was examined. Guidance concerning prevention of mold growth was provided to the North Andover School Department in relation to a different school facility in March 2002. According to this guidance, the following general improvements can be made to avoid microbial growth within these structures:

1. Use of sloped roof with properly installed gutter and downspout system to drain rainwater.
2. Sitting the structure on a well-drained surface.
3. Surface run-off should be directed away from the structure.

4. The crawlspace under the structure should be well ventilated.
5. Check all caulking and/or flashing around windows and service posts, especially after moving a structure.
6. Maintain ventilation according to American Society for Heating, Refrigerating and Air-conditioning Engineers (Stewart, B., 2002).

During the BEHA assessment the modular classroom wing was unoccupied and undergoing complete renovations. Therefore a complete indoor air quality evaluation could not be conducted. However, once renovations are complete, BEHA staff would be happy to conduct a follow-up assessment of the building.

Other Concerns

Several other conditions that can potentially affect indoor air quality were identified during the visit. The faculty workrooms have photocopiers and lamination machines. Lamination machines can produce irritating odors during use. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). School personnel should ensure that local exhaust ventilation is activated while equipment is in use to help reduce excess heat and odors in these areas.

Accumulated chalk dust and dry erase board particulate was noted in several classrooms. A few rooms had missing and/or dislodged ceiling tiles. Missing/dislodged ceiling tiles can provide a pathway for the movement of drafts, dusts and particulate matter between rooms and floors. Chalk dust and dry erase board particulates can be easily aerosolized and serve as eye and respiratory irritants. In addition, materials such as dry erase markers and dry erase board cleaners may contain VOCs (e.g., methyl isobutyl

ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can also be irritating to the eyes, nose and throat.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate. These items (e.g., papers, folders, boxes, etc.) also make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

One classroom contained time-released air fresheners (see Picture 11). Air fresheners contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. In addition, air fresheners do not remove materials causing odors, but rather mask odors, which may be present in the area.

Several areas contained window-mounted air conditioners. This equipment is normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter. Accumulated dust and particulates were also noted on the blades of portable fans (see Picture 12). When fans or FCUs are activated these materials can become aerosolized.

Cleaning products were found on counter tops in classrooms. Cleaning products contain chemicals (such as bleach or ammonia-related compounds), which can be irritating to the eyes, nose and throat. These items should be stored properly and out of the reach of students.

Several inactive wasps nest were noted in classrooms, which serve as learning tools. Insect parts can become dried out and aerosolized and may serve as a source of allergenic material for certain sensitive individuals.

Lastly, a number of classrooms contained upholstered furniture and/or pillows. In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, M.A., 1994). It is also recommended that upholstered furniture (if present in schools), be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate *continuously* during periods of school occupancy independent of classroom thermostat control.
2. Repair and/or replace thermostats as necessary to maintain control of comfort.
3. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
4. Remove all blockages from univents and exhaust vents.

5. Consider having the ventilation systems balanced by an HVAC engineering firm in accordance with Standard 111, SMACNA's HVAC Systems-Testing, Adjusting and Balancing, 2nd Edition.
6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Replace any remaining water-stained ceiling tiles and building materials. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
8. Inspect rooftop drains regularly to ensure proper drainage.
9. Seal expansion joints and around foundation to prevent moisture intrusion and subsequent water damage.
10. Remove plant growths against the exterior wall/foundation of the building to prevent water penetration. Trim trees in rear of building away from brickwork.
11. Ensure plants are equipped with drip pans and avoid over watering. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.
12. Consider having windows in the modular classroom replaced or proper flashing installed to prevent further water intrusion.
13. Store cleaning products properly and out of reach of students.
14. Replace missing/damaged ceiling tiles, to prevent the egress of dirt, dust and particulate matter into classrooms.

15. Clean chalkboards and trays regularly to avoid the build-up of excessive chalk dust.
16. Operate local exhaust ventilation in teacher's workroom during photocopier and lamination machine use.
17. Consider removing wasp's nests from classrooms.
18. Clean portable fan blades and exhaust vents periodically of accumulated dust.
19. Refrain from using strong scented (e.g. plug-in air fresheners) and/or VOC-containing materials.
20. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
21. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.

References

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Picture 1

Univent Return Vent Obstructed by Various Items

Picture 2

Items Obstructing Airflow into Classroom Exhaust Vent

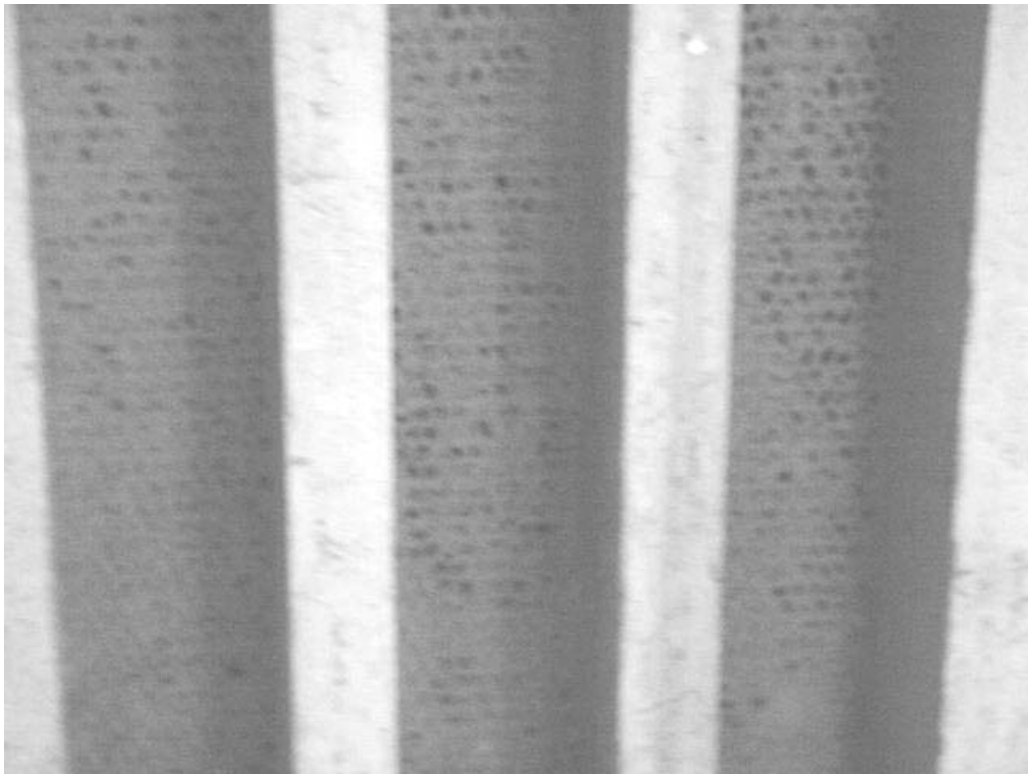
Picture 3

Proximity of Classroom Exhaust Vent to Open Hallway Door

Picture 4

Cafeteria Exhaust Vent under Stage

Picture 5



Close-up of Cafeteria Exhaust Vent (see Previous Picture) Occluded with Dust

Picture 6

Water Damaged Ceiling Tiles

Picture 7

Condensation between Window Panes in Modular Classroom

Picture 8

Space at Expansion Joint/Exterior Wall

Picture 9

Missing/Damaged Caulking between Foundation/Exterior Wall Panel

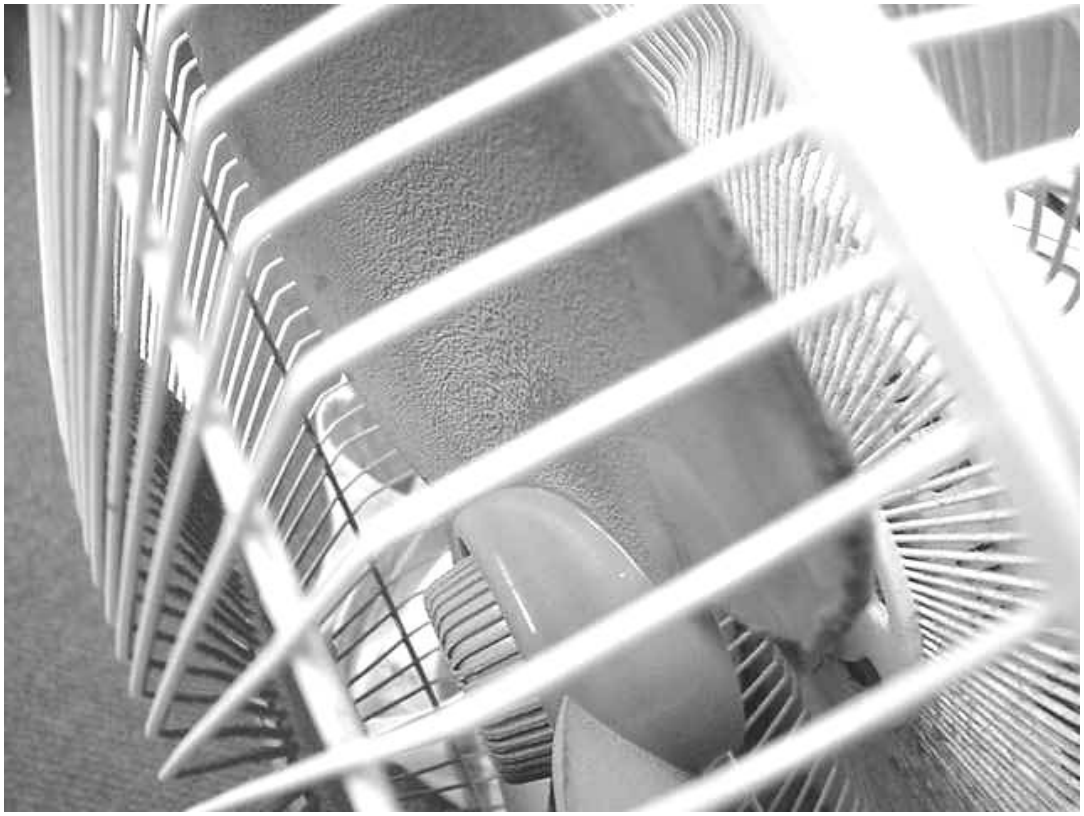
Picture 10

Trees/Plants Growing against the Foundation of the Building

Picture 11

Plug-in Air Freshener

Picture 12



Accumulated Dust on Fan Blades in Classroom

TABLE 1

Indoor Air Test Results – Atkinson Elementary School, North Andover, MA – March 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	305	44	49					Breezy
2nd Floor Girl's Restroom					Yes		Yes	Window open
2nd Floor Boy's Restroom					Yes		Yes	Window open
Room 11	856	72	28	0	Yes	No	No	Window and door open, carpet, accumulated items, dry erase board
Room 12	1091	73	29	22	Yes	Yes	Yes	Window and door open, carpet, 4 computers, 4 plants, aquarium, exhaust vent near door
Room 13	1222	73	29	18	Yes	Yes	Yes	Window and door open, univent obstructed, cart obstructing exhaust, accumulated items, 4 computers, 2 plants
Room 14	1181	73	28	19	Yes	Yes	Yes	Window open, univent off, exhaust vent near door, chalk dust, carpet, 3 water-damaged CT, 1 CT ajar

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Atkinson Elementary School, North Andover, MA – March 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 15	1095	75	29	20	Yes	Yes	Yes	Window open, carpet, wasp nest, aquarium, 4 plants, pillows/carpet, accumulated items, food
Room 7	1280	76	29	20	Yes	Yes	Yes	Ceiling-mounted univent, exhaust vent near door, door open, carpet, accumulated items, upholstered furniture, 4 computers, chalk dust
Room 8	1235	74	26	18	Yes	Yes	Yes	Exhaust vent near door, door open, holes in CT, 5 computers, area rug, plant, chalk dust, dry erase board
Room 9	1089	73	26	22	Yes	Yes	Yes	Univent off, exhaust blocked by bookcase, carpet, door open, dry erase board, window-mounted air conditioner-draft
Library	546	73	24	2	Yes	Yes	Yes	Books/carts obstructing univent, desk obstructing exhaust, carpet, 6 plants, 2 window-mounted air conditioners, door open
Teacher's Lounge	664	73	25	2	Yes	No	Yes	window-mounted air conditioner, exhaust-wall fan, lamination machine, photocopier, sink, refrigerator, elec. stove, 2 water-damaged CT

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TABLE 3

Indoor Air Test Results – Atkinson Elementary School, North Andover, MA – March 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Cafeteria	535	74	24	5	Yes	Yes	Yes	3 univents, exhaust-under stage/vents occluded with dust/off-no draw, ceiling fans
Kitchen	516						Yes	
Main Office	602	73	23	2	Yes	No	No	Window open, photocopier, window-mounted air conditioner, ~13 plants
Nurse's Office	687	73	24	1	No	No	Yes	Exhaust vent in adjacent restroom, door open, 2 water-damaged CT, 1 broken CT, sink, refrigerator
Principal's Office	598	74	24	0	Yes	No	No	Window-mounted air conditioner, carpet, door open
Sped Office	688	74	25	0	Yes	No	No	Carpet, door open, spray cleaner on shelf
Portable Classroom Corridor Roof								Pooling water-drain clogged/ improperly pitched
Portable Classroom								Under renovation, condensation between window panes
Gymnasium	642	9	21	20	Yes	Yes	Yes	Thermostat issues, weak exhaust, exterior door and windows open

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TABLE 4

Indoor Air Test Results – Atkinson Elementary School, North Andover, MA – March 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Art Room	931	75	18	2	Yes	Yes	Yes	Former locker room, 2 univents, window open
Music Room	1580	76	28	21	No	Yes	Yes	3 water-damaged CT, exhaust vent partially blocked-weak/no draw
Room 6	1220	74	25	17	Yes	Yes	Yes	Exhaust vent in corner-partially blocked, dusty fan, water-damaged CTs along back wall
Room 5	1180	75	27	27	Yes	Yes	Yes	Door open, 5 plants
Room 4	677	75	23	4	Yes	No	No	Room divided into offices
Speech/Language Therapy Room	520	75	21	2	Yes	No	No	Sneezing-allergies-heat complaints
Cafeteria	766	75	25	~200	Yes	Yes	Yes	See above
2nd Floor Hallway								Water-damaged CT near room 15
Room 16	864	73	27	0	Yes	Yes	Yes	Exhaust vent partially blocked, window open
Room 17	1030	74	28	0	Yes	Yes	Yes	Door open, 2 plants

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TABLE 5

Indoor Air Test Results – Atkinson Elementary School, North Andover, MA – March 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 18		72	31	30	Yes	Yes	Yes	Exhaust vent obstructed by TV cart, univent off, door open, 5 plants
Room 19	1520	74	33	19	Yes	Yes	Yes	3 plants
Room 20	1233	70	32	16	Yes	Yes	Yes	Door open, items on/in front of univent, temperature complaints-cold/reports thermostat set at 90° F to get heat
Main Entrance Awning								Standing water-no drainage, moss growth
Perimeter Notes	No gutters/downspouts, moss growth (north side), spaces-brick/window frame (east side), spaces-slab/brick							

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